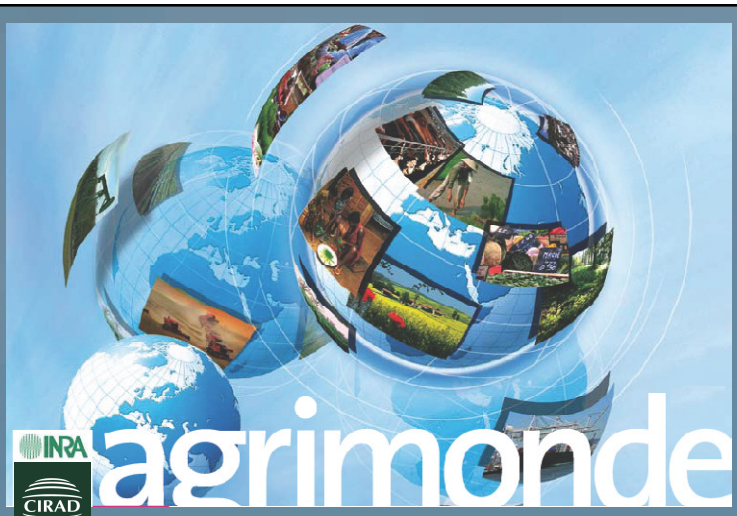

Scenarios and challenges for feeding the world in 2050

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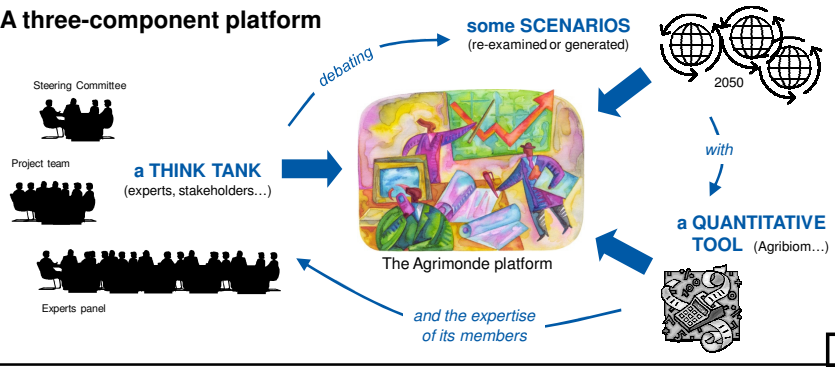
CGIAR SRF Technical Design & Implementation Meeting, 22-23 July 2009, IFPRI, Washington DC

The foresight exercise Agrimonde (introduction)

- **A joint INRA-CIRAD project** (2006-2008 = 1st phase)
  - French National Institute for Agricultural Research (www.inra.fr)
  - French Agricultural Research Centre for International Development (www.cirad.fr)
  - → under their common group **IFRAI** (French Initiative for International Agricultural Research)
- **Objectives**
  (1) to explore possible futures of food and farming systems up to 2050
  (2) to design and debate orientations and strategies for INRA - CIRAD research agendas
  (3) to contribute to international debates on food, agriculture and the environment
- **A three-component platform**



Part I

Aims & architecture of Agribiom

A quantitative module designed for facilitating
collective explorations and debates
as well as hybrid modeling
relating to global productions, trade and uses of biomasses

❶ The ambition for Agrimonde

Having a quantitative tool for :

(1) revisiting the past, better understand it (with new estimates, new models…)

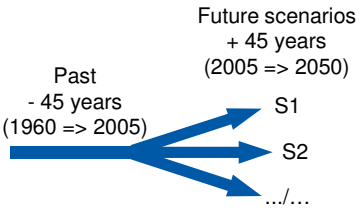
(2) debating the future
...from scenarios description (own or external qualitative conjectures)

reflected / summarized into few quantitative parameters (populations, diets, non-food uses land uses, productivities…)

Global Consistency ? (physical equilibrium between biomass uses & resources)

Implications ? (international trade, energy & water consumptions…)

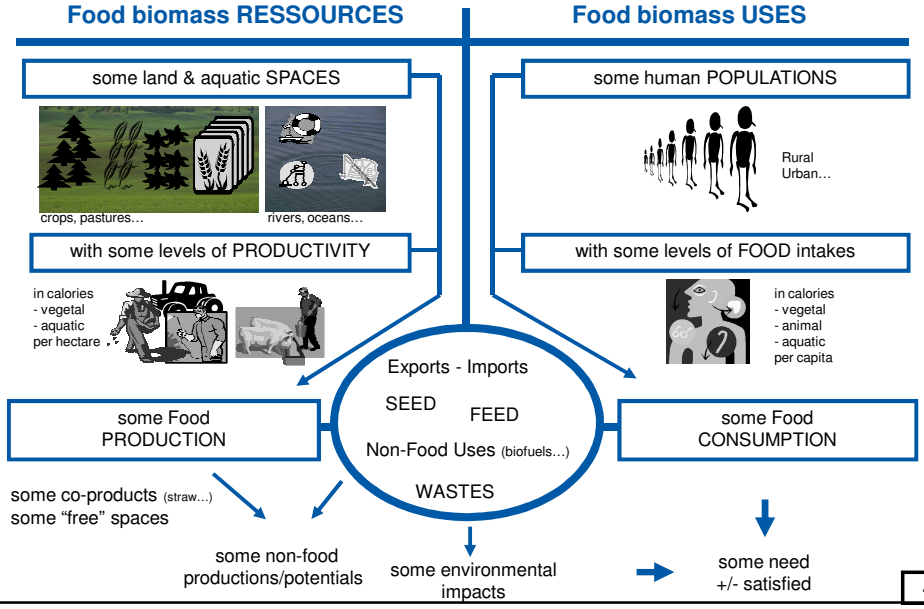
Impact of variants ? (populations, composition of diets…)



3

❷ The engine

S/U physical equilibriums of food biomasses
reconstituted (1961-2003, out of FAOSTAT commodity balances in metric tons)
and/or simulated (2030, 2050…)
on more than 97% of the world land surfaces (149 basic «regions»)



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❸ The items

- 5 « compartments » of food biomasses (only…)
- Other productions (non-food…)
  Fibres, Tobacco, Rubber… Fodders …Wood

PLANTS (VEGE)

Cereals : wheat, rice, barley, maize…
Sugar crops : sugarcane, sugar beat…
Pulses : beans, peas…
Oilseeds : soybean, groundnut, coconut…
Roots & tubers : cassava, potato…
Fruits & vegetables : apple, onion…
Stimulants : cocoa, coffee, alcohol…

GRAZING ANIMALS (RUMI)
Meats : bovines, goat, mutton…
Milk, Butter, Animal fats…

Non-GRAZING ANIMALS (MONO)
Meats : poultry, pig…
Eggs…

FRESH WATER (AQUA)
Fishes…

MARINE (MARI)
Demersal & Pelagic fishes… Fats…

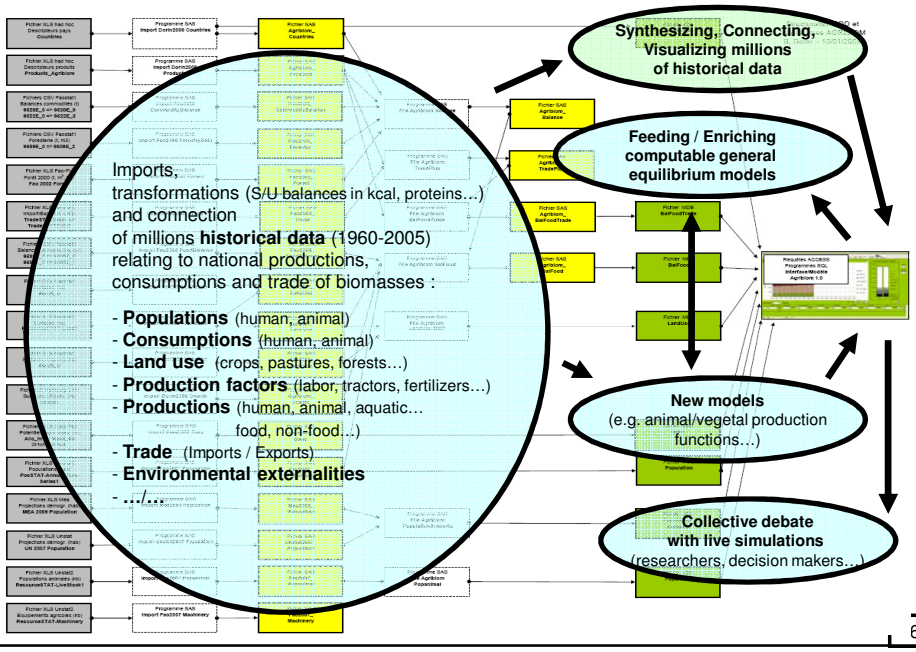
1961-2003 : 120 product lines of Faostat1 (SUA - *Commodity Balances*)

❹ The unit of account

- Food CALORIES
  (or equivalent for oilcakes, molasses…)
  Total Calories = Carbohydrates (4 kcal/g)
  + Proteins (4 kcal/g)
  + Fat (9 kcal/g)
- Tonnes (ou m^3) of DM
  - Fibres, rubber…
  - Crop residues…
  - Fodders…
  - Wood (fuel or industrial wood)

5

❺ A convergence on an interactive interface



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❻ A 1st set of robust models

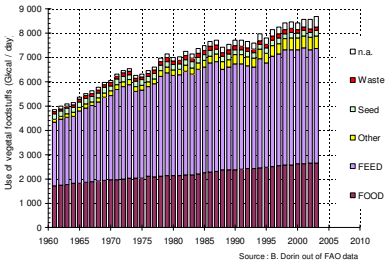
Cross-country animal production functions
(B. Dorin + T. Le Cotty)

- A model with **2 interdependent functions**
  - Prod_Rumi (Gkcal) = f (x1,x2, x3…, Prod_Mono)
  - Prod_Mono (Gkcal) = f (x1,x2, x3…, Prod_Rumi)

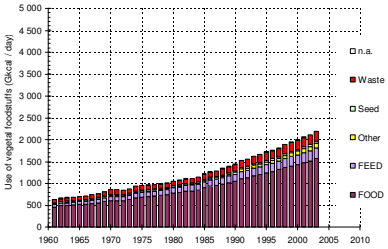
- Key explaining factors (x1, x2, x3…) :
  - **Feed of vegetal origin** (Gkcal)
  - **Feed of animal origin** (Gkcal)
  - **Pasture area** (1 000 ha)
  - Agricultural active population (1,000 cap)
  - Tractors (units)
  - …/…

OECD

SSA
(Sub-Saharan Africa)



(in 2003, the OECD cattle ate 3 times as much foodstuff as the SSA human population did)



- Several models now available :
  - **linear** / quadratic
  - CalTot / **CalPro** (unit for the feed and for the outputs…)
  - with/**without «Dummies»** (region, years…)
  - with/**without «Trend»** ("technical progress")
  - «**Region-based**» (MEA regions…) or «Type-based» (agricultural/industrial, extensive/intensive…)
  - …/…

- Results :
  - replicate very-well the past 40-year of national/regional/global animal productions
  - "on-line" tests and modeling (choice of model, change of parameters/coefficients, simulations…)

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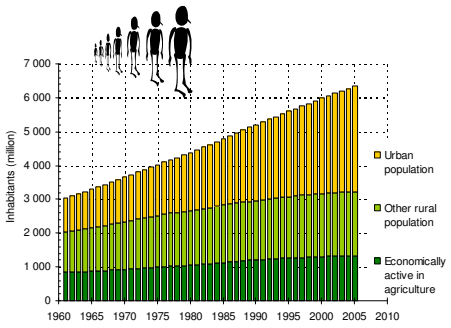
Part II

From past trends to scenarios

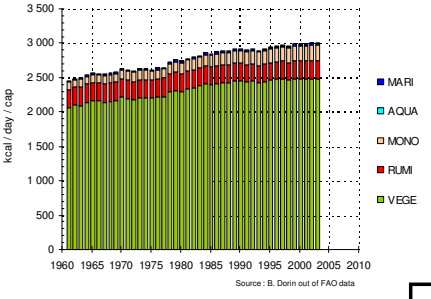
A 1961-2003 brief overview of the world food economy through Agribiom eyes…

❶ From average world increases…

- The population doubled



- The per-capita food availability increased too…



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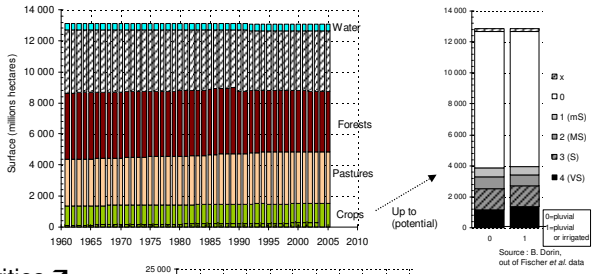
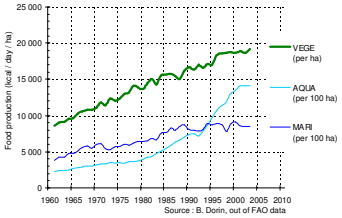
On the resources side:

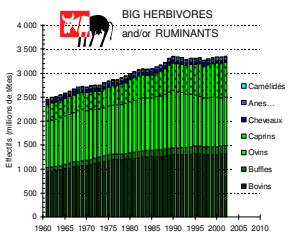
- Agricultural area ↗
  - Pastures : + 11%
  - Crops : + 13%

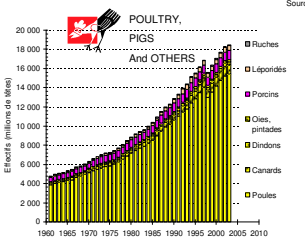


- Land and labour productivities ↗
  - Veg calories / cultivated ha : + 123%
  - Veg calories / farmer : + 53%



- Livestock ↗





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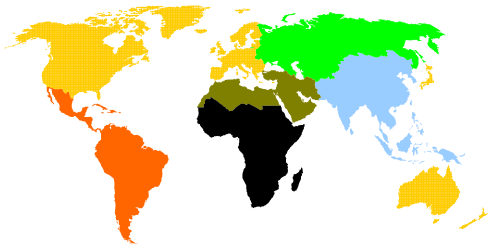
❷ ...to regional disparities

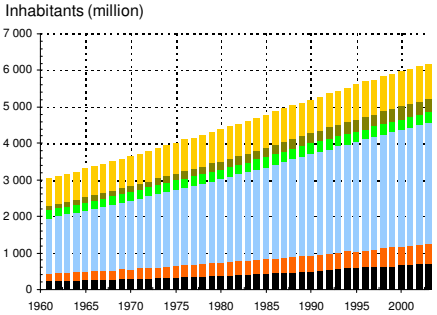


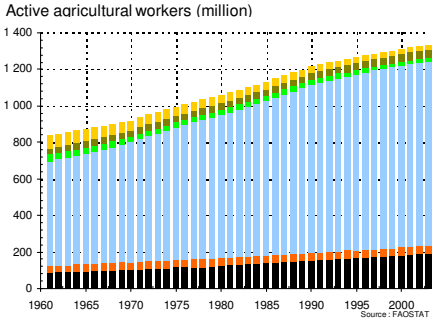
The 6 MEA regions

- OECD = Oecd-1990
- MENA = Middle East & North Africa
- FSU = Former USSR
- ASIA = Asia
- LAM = Latin America & the Caribbean
- SSA = Sub-Saharan Africa

- Human populations

Farmers : highly and increasingly concentrated in Asia and Africa





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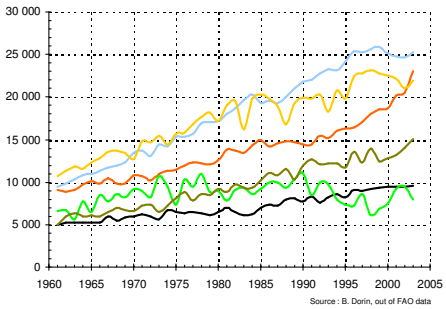
- Highest land productivity in ASIA

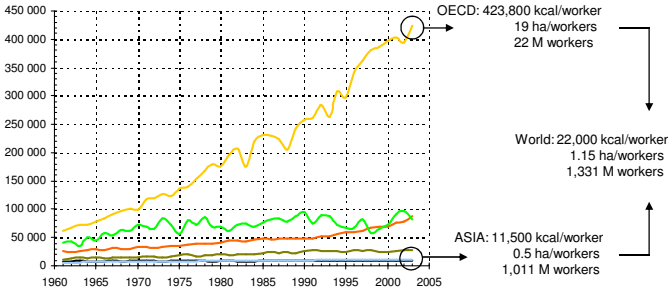
Vegetal kcal / day / cultivated hectare



Note : 10 000 kcal =
~ 2.4 kg of soybean
~ 2.8 kg of rice milled
~ 2.9 kg of pea
~ 3.0 kg of wheat
~ 15.0 kg of potato
~ 58.8 kg of tomato

- A labour productivity boom in OECD

Vegetal kcal / day / agricultural worker



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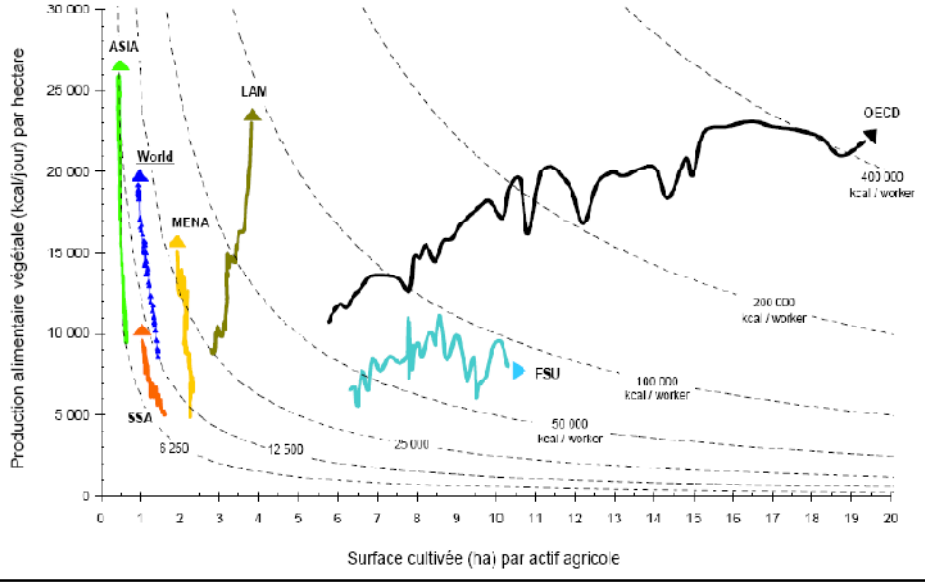
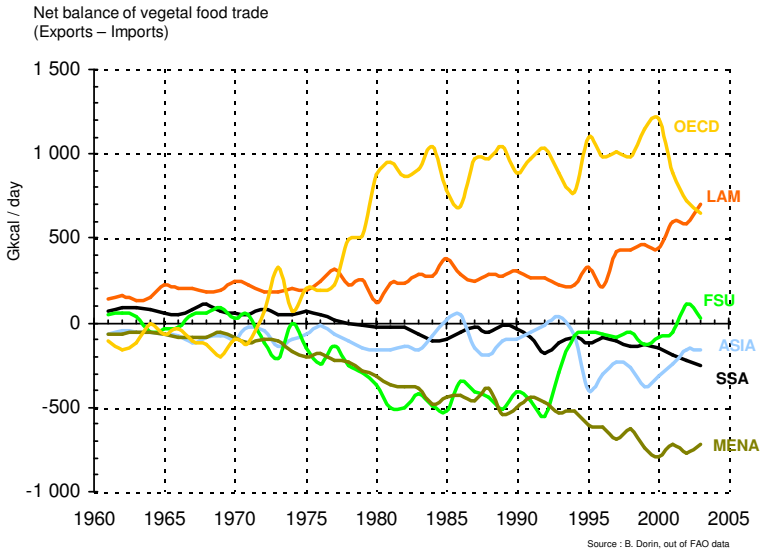
Crop yields (kcal/d/ha) / Labor productivity (ha/worker) (1961 – 2003). Source : B. Dorin



A boom of food trade to clear surpluses and fill in deficits



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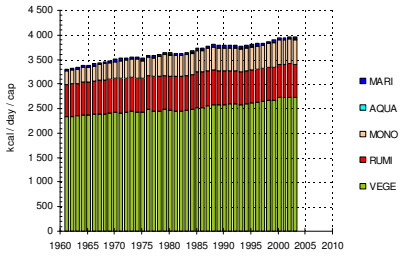
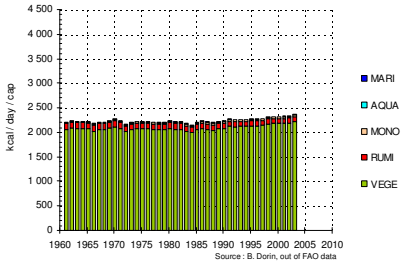
But still very large disparities in per-capita food availabilities



OECD

- Animal proteins : 71 g / day on 125 (60%)
- Animal fats : 89 g / day on 165 (55%)



Sub-Saharan Africa

- Animal proteins : 12 on 60 g / day (20%)
- Animal fats : 10 on 48 g / jour (20%)

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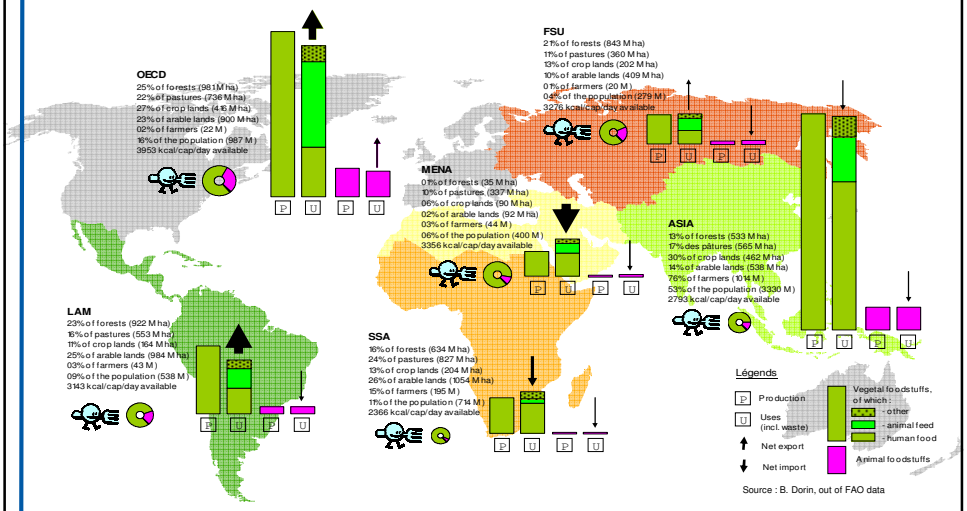
❸ Towards which new «equilibrium» in 2050 ?

- Resources, productions, trade and uses of food biomasses (2003)

http://www.cirad.fr/upload/en/communique/Cirad-Inra-Agrimonde-GB.pdf



- Scenarios, hypotheses, collective debates… (2050) ← Agribiom simulations

Part III

Scenarios and challenges for feeding the world in 2050

Two first explorations by Agrimonde : the "AGO" and "AG1" worlds

❶ Towards which new «equilibrium» in 2050 with…

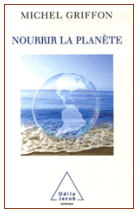
- +/- population growth (7-11 billions inhabitants in 2050) ?
- +/- incomes, incomes distribution and population migrations (regional opportunities of decent incomes, self-subsistence…) ?
- +/- change in food diets (vegetal/animal, macro/micro nutrients…) ?
- +/- demand in non-food products (bio-energies, bio-materials…) ?
- +/- economic liberalization and trust in international trade ("sovereignty" in cereals / other basic vegetal foodstuffs / feed for animal productions / animal foodstuffs…) ?
- +/- environmental regulations (forests, greenhouse gases, biodiversity…) ?
- +/- important crisis on present yield boosts (fossil fuels, water, pesticides, phosphates…) ?
- +/- climate change
- …/…

❷ The “AGO” and “AG1” worlds

- Two scenarios “reprocessed”

The *Doubly Green Revolution* scenario

Source: Griffon M., 2006. Nourrir la planète. Pour une Révolution doublement verte, Odile Jacob, Paris



The Green Revolution, which was introduced on a world scale after World War II, made it easy to ignore the threat of hunger. But the Green Revolution also encouraged overpopulation; it ravaged the environment in many places; it created inequalities in the sharing of the planet's wealth, and these inequalities have made the threats we must face in the coming decades even greater than those the world had to confront in the early twentieth century.

Agrimonde platform

The “Agrimonde 1” scenario (AG1)

The “Agrimonde GO” scenario (AGO)

The *Millennium Ecosystem Assessment* scenarios

Source: MEA, 2005. Ecosystems and Human Well-being: Scenarios, The Millennium Ecosystem Assessment, Washington DC.

Global Orchestration

A globally connected society that focuses on global trade and economic liberalization and takes a reactive approach to ecosystem problems but that also takes strong steps to reduce poverty and inequality and to invest in public goods such as infrastructure and education. Economic growth in this scenario is the highest of the four scenarios, while it is assumed to have the lowest population in 2050.

Globalization

Techno-Garden

A globally connected world relying strongly on environmentally sound technology, using highly managed, often engineered, ecosystems to deliver ecosystem services, and taking a proactive approach to the management of ecosystems in an effort to avoid problems. Economic growth is relatively high and accelerates, while population in 2050 is in the midrange of the scenarios.

Reactivity

Proactivity

Order from Strength

A regionalized and fragmented world, concerned with security and protection, emphasizing primarily regional markets, paying little attention to public goods, and taking a reactive approach to ecosystem problems. Economic growth rates are the lowest of the scenarios (particularly low in developing countries) and decrease with time, while population growth is the highest.

Adapting Mosaic

Regional watershed-scale ecosystems are the focus of political and economic activity. Local institutions are strengthened and local ecosystem management strategies are common; societies develop a strongly proactive approach to the management of ecosystems. Economic growth rates are somewhat low initially but increase with time, and population in 2050 is nearly as high as in Order from Strength.

Regionalization

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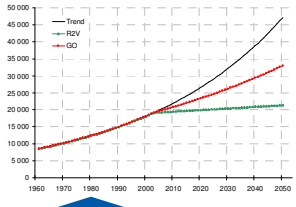
- Main quantitative assumptions

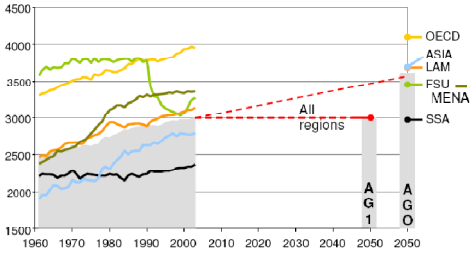
		2003	2050 - AG1	2050 - AGO
Uses	Population	6.2 Gcap	8.8 (+42%)	8.8 (+42%)
	Human food	3,000 kcal/day/cap 17% Non-Veg	**3,000** **17%** Non-Veg	**3,590** (+19%) **23%** Non-Veg
	Other uses	~14,440 Gkcal/day	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)
Ressources	Food yields	~19,190 kcal/day/ha	~20,030 (**+4%**)	~32,940 (**+75%**)
	Crop land - for N-Food	~1,530 Mha neg.	~2,105 (**+38%**) 224 Mha	~1,860 (**+21%**) 217 Mha
	Pastures	~3,330 Mha	~2,845 (**–14%**)	~3,585 (**+8%**)
	Forest	~3,905 Mha	no change	+14% (?)

kcal/day/ha

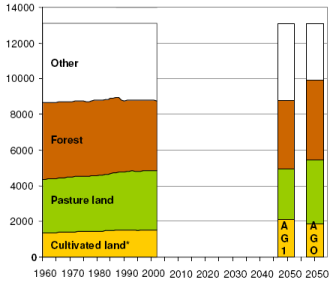


Trade : trade of plant food only (i.e. no trade of animal foodstuffs or by-products) (hypothesis/variant n°1 written “h01”)

kcal/day/cap



Mha



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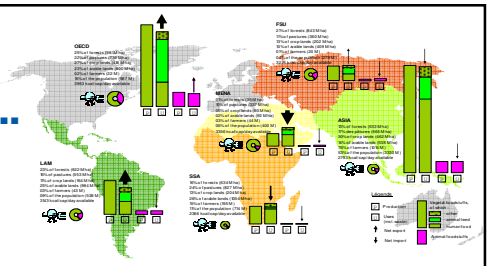
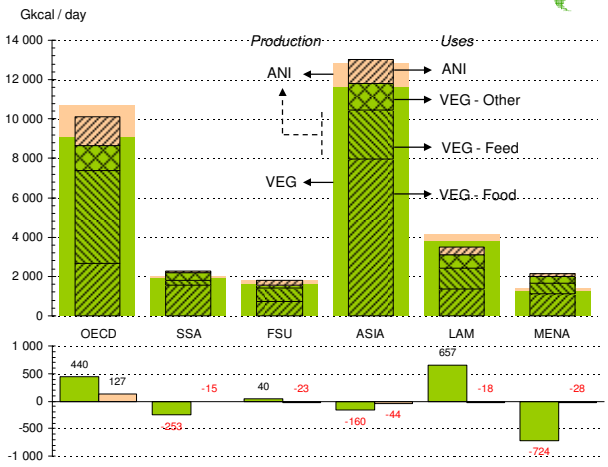
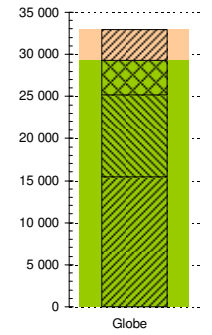
❸ Two new hypothetical equilibriums for 2050...



- Base 2003





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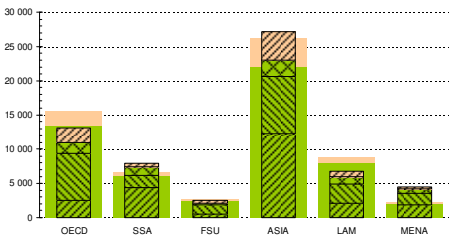
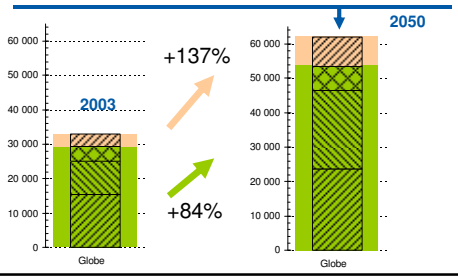
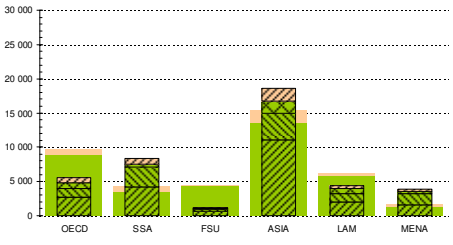
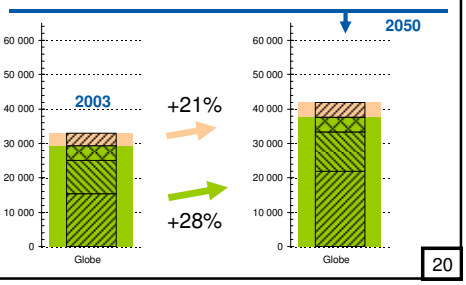
- Scenario 2050 - AGO **AGO.h01**





- Scenario 2050 - AG1 **AG1.h01**





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❹ Amongst conclusions…

The planet can feed properly 9 billions people in 2050 but…

- What is in our plates (total calories, %Veg/Ani, macro/micro-nutrients…) is a key driver for:
  - preserving some ecosystem services (carbon sequestration, soil, water, pollination…) and/or saving the use of some agricultural inputs (water, fertilizers, pesticides…)
  - reducing some important human health problems (from under-nutrition to obesity)
  - opening larger opportunities for non-food productions (bio-energies, biomaterials…) and reducing substantially post-harvest losses and food wastes
  - maintaining a diversity of production systems, landscapes and environments
- Food trade can secure some regional food needs and avoid huge migrations, provided the net-deficit regions/populations can:
  - pay for their food imports (local opportunities of incomes?)
  - rely on a fair and transparent international trade regulation system ...also aware of poor farmers incomes

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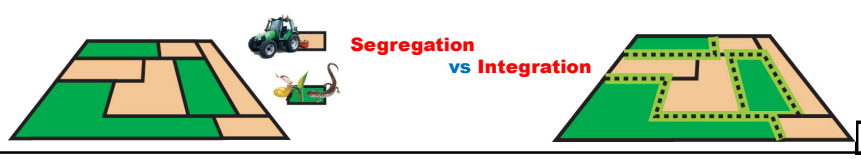
- Preserving or improving agricultural yields calls for breakthroughs:

(a) Need for much less polluting & less dangerous techniques (for workers, flora, fauna…) founded on:
- much better exploitation of ecosystem services (pollination, IP…)
- new technologies (ITC, genetics, monitoring…)
- mobilizing jointly scientific & local knowledge (social learning processes)

(b) "Ecological intensification" might emerge as an interesting option for sustainable biomass production and food security of poor farming families, provided we don't stay locked-in a 50 year-old model of agricultural intensification

(c) The yield/area dilemma might be an opportunity to overcome usual boundaries between cities, wider countryside & natural areas:
- urban & peri-urban agriculture…
- agro-forestry, agro-ecology…
- stewardship of wet areas (…and not only draining them)
- complementarities between differentiated areas (…and not setting land aside)

Dilemma production/conservation



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If Recommendations …
(1) Food policies able to:

- - promote diets based on a consumption of various foodstuffs (cereals, oilseeds, pulses, roots and tubers, fruits and vegetables… eggs, milk, meats… fishes) both in a sufficient and reasonable way, as well as adapted to local food cultural preferences, so that important and growing human health problems can be tackled, from under-nutrition to obesity or cardio-vascular diseases
- - limiting as far as possible the present huge post-harvest and/or post-purchasing wastages of food

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If recommendations …
(2) Agricultural policies able to:

- - encourage in the long run Low-Input High-Diversity systems of agricultural productions, in order to enhance (i) less polluting and less dangerous agricultural techniques (for workers, flora, fauna, soils, water…) (ii) the resilience of agriculture to economic, energetic or climatic crises, (iii) the annual biomass production per hectare through judicious local combinations of various vegetal and animal species (iv) employment and food security in rural areas
- - boost in the short run the access of small farmers in developing countries (especially in Africa) to national and international markets (roads, internet…) as well as to cheap credit and to traditional agricultural inputs (irrigation, fertilizers, seeds…)
- - if “productivity” (yields) relates to technology (i.e. research inputs among others) and farmers’ know-how, “production” relates to policy decisions regarding land tenure, producers’ organizations, farmers’ capacity building, access to credit, property rights, etc.

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If recommendations …

(3) Trade and competition policies able to:

- - encourage the formation in the world of several large regional free-trade and sovereign areas for food
- - safeguard day-to-day imports and export of basic foodstuffs between these areas especially in case of crises
- - fight efficiently against market powers which erode farmers incomes because of high prices upstream (inputs bought from an oligopsony of multinaltionals) and low prices downstream (outputs sold to an oligopoly of traders, processors or distributors).

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To follow up…

- Need to involve a large set of actors, stakeholders …and academic disciplines into food production, food security, food safety and food quality issues!
- Need to debate food and agriculture scenarios at various regional levels (…with various stakeholders)
- Need to better simulate (with Agribiom and other quantitative tool)
  - induced consumptions of fossil fuel and water
  - GHG emissions/sinks (C, CO_2, CH_4, N_2O…)
  - regional employments / incomes / migrations
  - …/…

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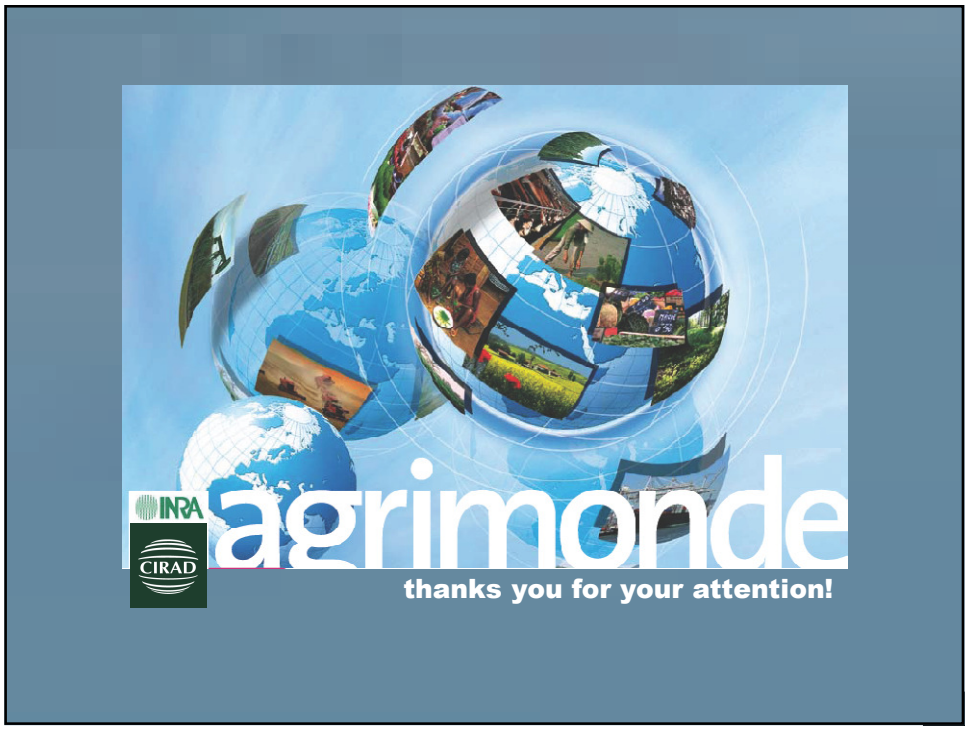
INRA
CIRAD
agrimonde
thanks you for your attention!


Param
UTIL
PROD
EXIM
Delta
Population (Kcap)
Rations (kcal/j/cap)
FOOD (Gkcal/j)
FEED
VANA
SEED
WAST
Résidu
Total (Gkcal/j)
Surfaces (Kha)
Rendement (kcal/j/ha)
Production (Gkcal/j)
Exp - Import (Gkcal/j)
1 OCDE 1990
1 066 211
2 Afrique Sub-Saharienne
1 662 000
3 Ex-URSS
239 212
4 Asie
4 427 101
5 Amérique Latine
773 659
6 Moyen Orient et Afrique du Nor
631 364
TOTAL Zone
8 800 147